

GRID MODERNIZATION INITIATIVE

PEER REVIEW

Interconnections Seam Study

1.3.33

AARON BLOOM

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

Interconnections Seam Study

1.3.33

Project Description

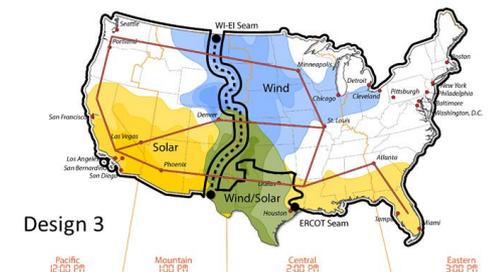
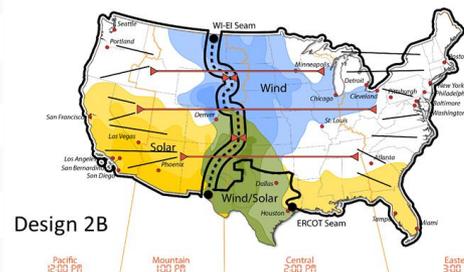
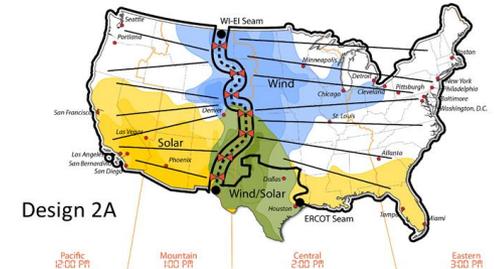
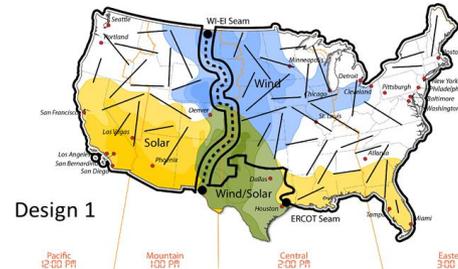
What are the options for large scale transmission expansion between the interconnections?

Project Objectives

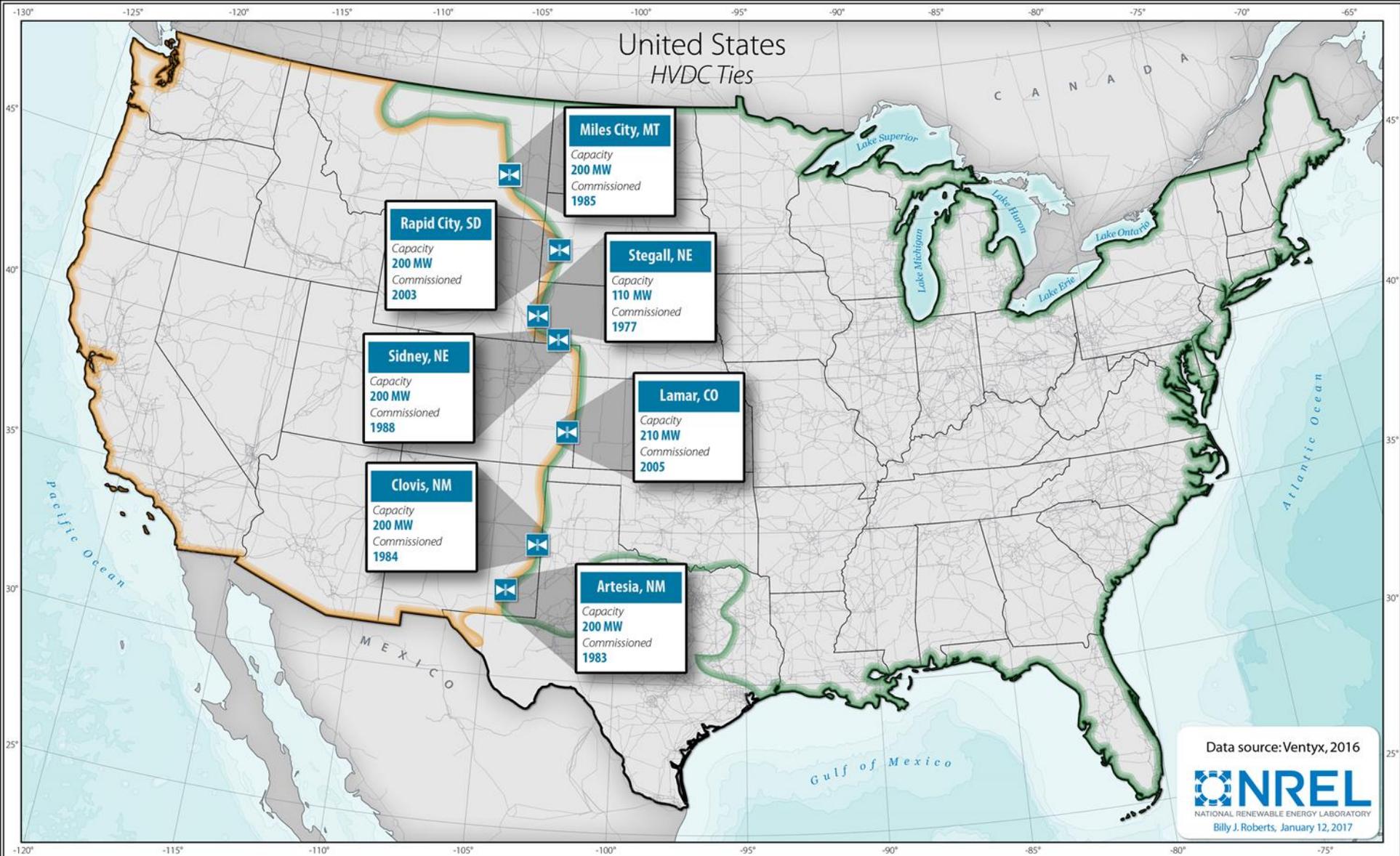
- ✓ Convene stakeholders
- ✓ Identify modern transmission options for connecting the interconnections

Value Proposition

- ✓ Increase electricity resilience
- ✓ Lower modernization costs through diversity
- ✓ Aging assets present an opportunity



What is the Seam?



Interconnections Seam Study

Project Team

Project Participants and Roles

- NREL
 - Project Lead
 - Production Cost Modeling
- PNNL
 - +1
 - AC Power Flow
- Iowa State University
 - Capacity Expansion Modeling
- ANL
- ORNL
- Management Team
 - Southwest Power Pool
 - Midcontinent Independent System Operator
 - Western Area Power Administration
- Technical Review Committee
 - 2 TRC Meetings, ~ **50 participants** at each event



NREL and SPP tour WAPA's Virginia Smith Converter Station

PROJECT FUNDING	
Lab	FY16 \$
NREL	532
PNNL	422
ISU	160
ANL	43
ORNL	43

Interconnections Seam Study

Relationship to Grid Modernization MYPP



MYPP Vision: The future grid will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation (...)

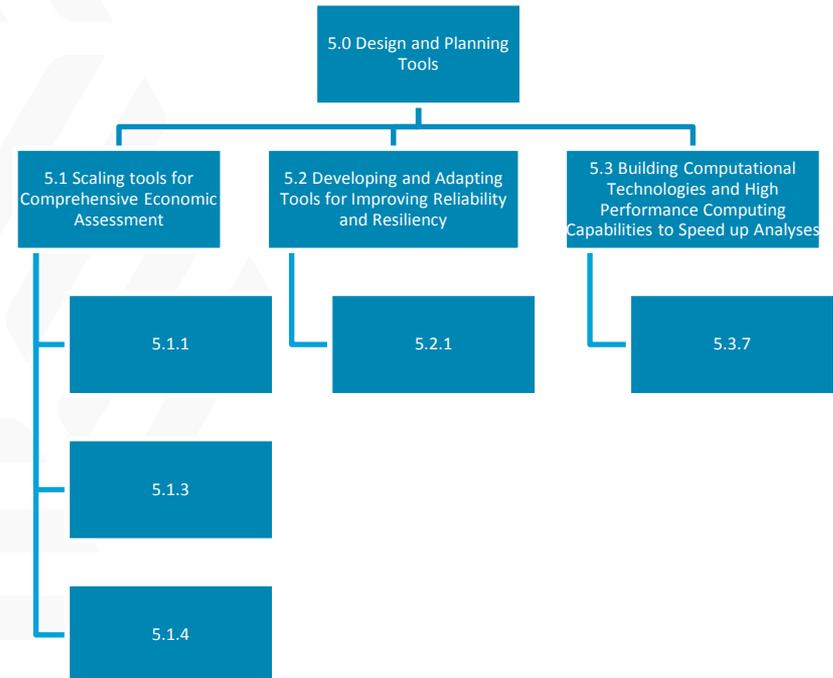
Direct relationship to MPYY vision by delivering a tool to ***estimate the value of national transmission planning***

5.1.1 – Task 5.1.1: Improve computational performance of production cost modeling for year-long sub-hour time resolution by decreasing run times from 2+ weeks to less than 1 day for (1) stochastic transmission and (2) deterministic combined transmission-distribution

5.1.3 – Develop advanced capacity expansion planning for generation, transmission, and distribution that captures operational flexibility, long and short term uncertainties, distributed energy technologies, market and policy impacts, and coupled network and generation optimization.

5.1.4 – Identify and classify data sources, define templates, and develop databases for new grid technologies, generation, load, and other components that compatible with modeling for high performance computers

5.2.1 –Develop scalable integration framework for dynamic modeling and simulation tools across transmission, distribution and communications for evaluation and design



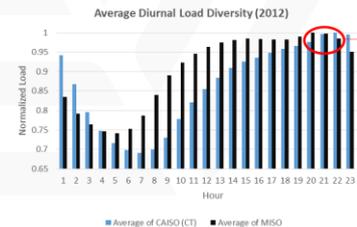
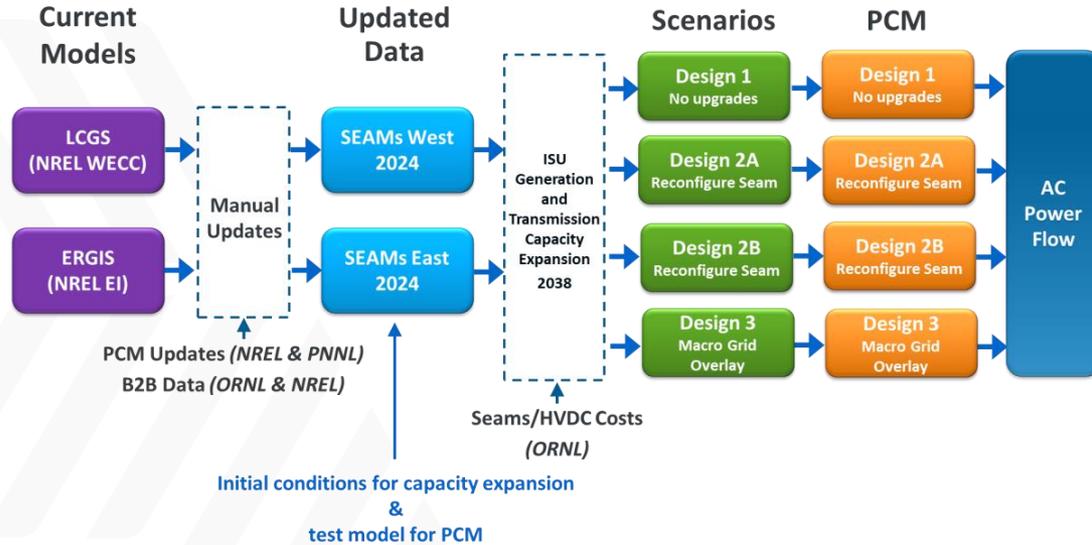
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Approach

Objective: Comprehensive economic and reliability analysis for transmission.

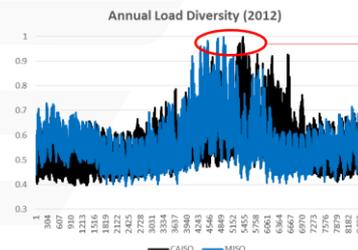
Critical Tasks

- Develop new co-optimized transmission and generation expansion model with Iowa State University
- Develop and verify new wind, solar and load data
- Develop a new production cost model
- Develop dynamic models of the eastern and western interconnections



Average diurnal load diversity

From CAISO to MISO $\rightarrow (46,675 \cdot .025) = 1,167$ MW
From MISO to CAISO $\rightarrow (96,769 \cdot .020) = 1,935$ MW



Annual load diversity

From CAISO to MISO $\rightarrow (46,675 \cdot .2) = 9,335$ MW
From MISO to CAISO $\rightarrow (96,769 \cdot .2) = 19,354$ MW

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Key Project Milestones



Milestone (FY16-FY18)	Status	Due Date
Finalize the development of the capacity expansion, production cost model and AC power flow models for the Base case. Perform preliminary simulations for the base case to test the proposed approaches	100%	4/1/17
Submit draft journal paper on the results of the capacity expansion, production cost, and AC power flow analysis to major industry or academic journal such as IEEE, Science, etc.	25%	10/1/17

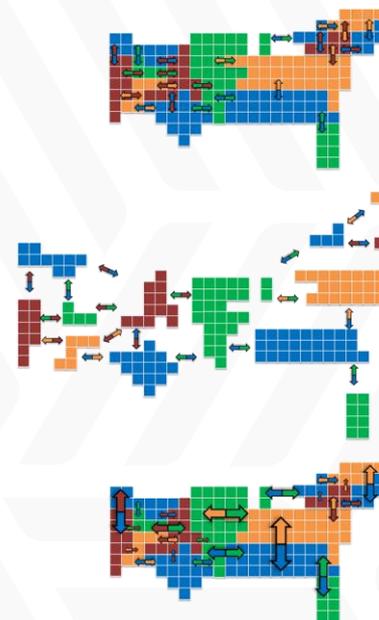
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Accomplishments to Date

Industry

- ▶ Technical Review Committee
 - ~50 participants
 - 2 in-person meetings
- ▶ Data Development
 - 2012 weather year
 - Unit specific heat rates
 - Topology and fleet
- ▶ Data sharing
 - Heat rates
 - Wind and solar

New Method: Geographic Decomposition



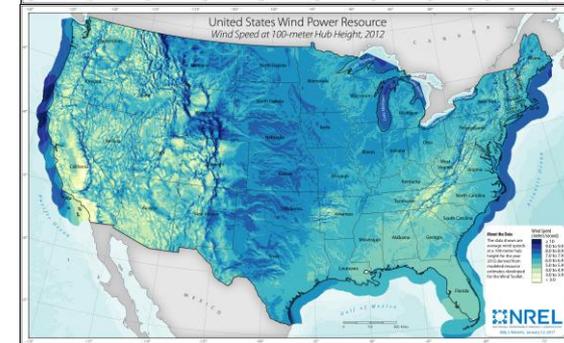
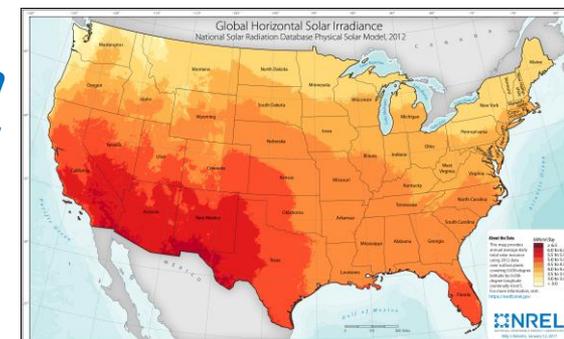
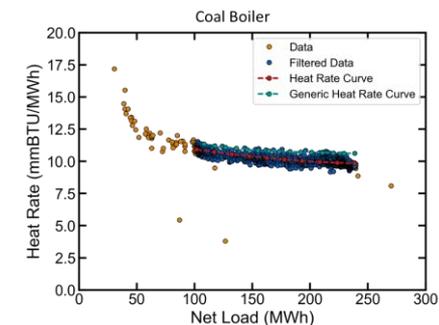
Solve time reduced from 60 to 25 hours on simplified ERGIS model!

Improved representation of real markets



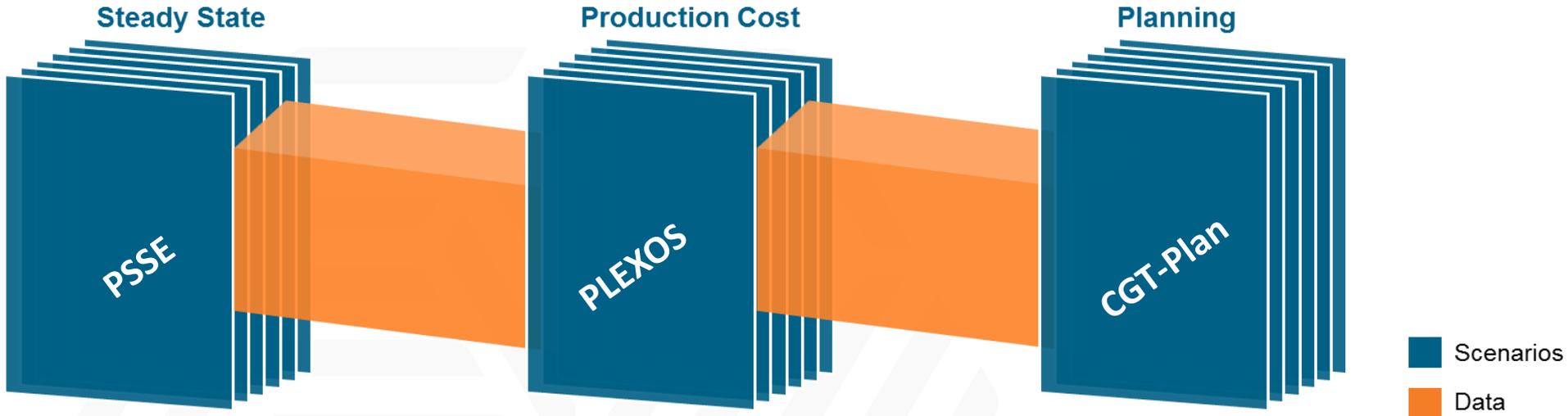
Data:

Deeper Insights



Interconnections Seam Study

Comprehensive least cost reliability analysis



- ▶ Analyzes the full breath of economic and reliability impacts of the four transmission scenarios
- ▶ High Performance Computing and Big Data using commercial tools
- ▶ Common data across tools
 - WECC TEPPC 2026 and MMWG 2026 power flow and transmission
 - Consistent thermal assumptions
 - Consistent VG assumptions

Interconnections Seam Study

Response to December 2016 Program Review



Recommendation	Response
Please be ready to develop communication materials for state governments. They will be very interested in the results of this work.	A state level communications package has been drafted. Budget is likely insufficient for this activity.
The visualization was very effective in demonstrating the results of this project.	As part of NARIS, a new visualization capability is being developed. The timeline should enable use in the Seams study.

Draft State Level Fact Sheet

Overview

At the western edge of the American prairie, just east of the Rocky Mountains, lies a collection of electrical resources that string together the workhorse of the American economy: the United States power system. Seven back-to-back high voltage direct current facilities enable 1,400 megawatts of electricity to flow between the Eastern and Western Interconnections. The 1,400 MW of transfer capability between the interconnections isn't much more than a rounding error compared to the size of the networks they connect—the larger Eastern Interconnection is home to 700,000 MW of generating capacity. But these facilities, located strategically where the East meets the West, are aging rapidly and they present a timely and impactful opportunity to modernize the U.S. electric grid. In the Interconnections Seam Study, the GMLC is investigating options for reconfiguring the electrical connections between the Eastern and Western Interconnection.

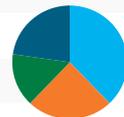
Why Nebraska Cares

Nebraska is home to two back to back HVDC facilities

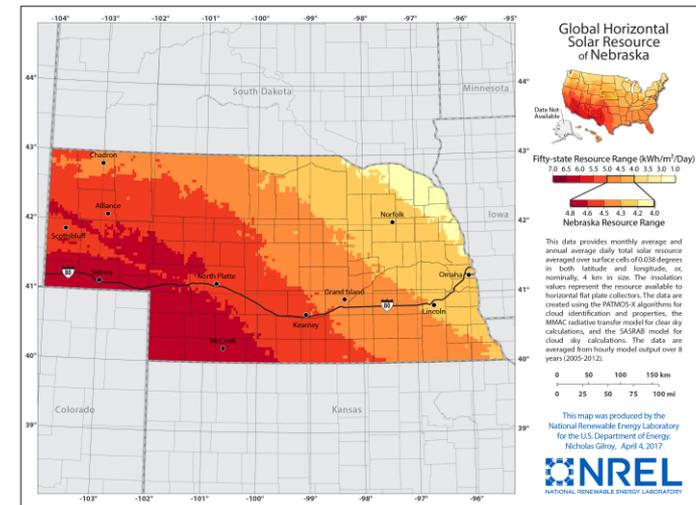
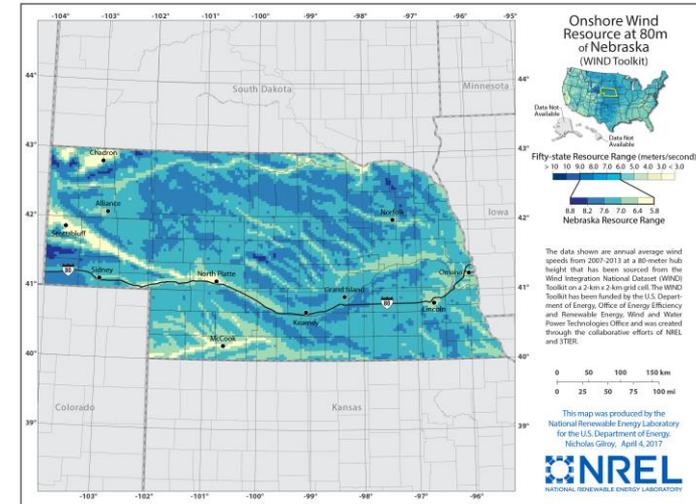
Nebraska by the Numbers

- Seams Facilities
- Installed generation
- Miles of transmission
- Generation today
- Generation in Seams Scenarios

Today's
Generation



Seams
Generation

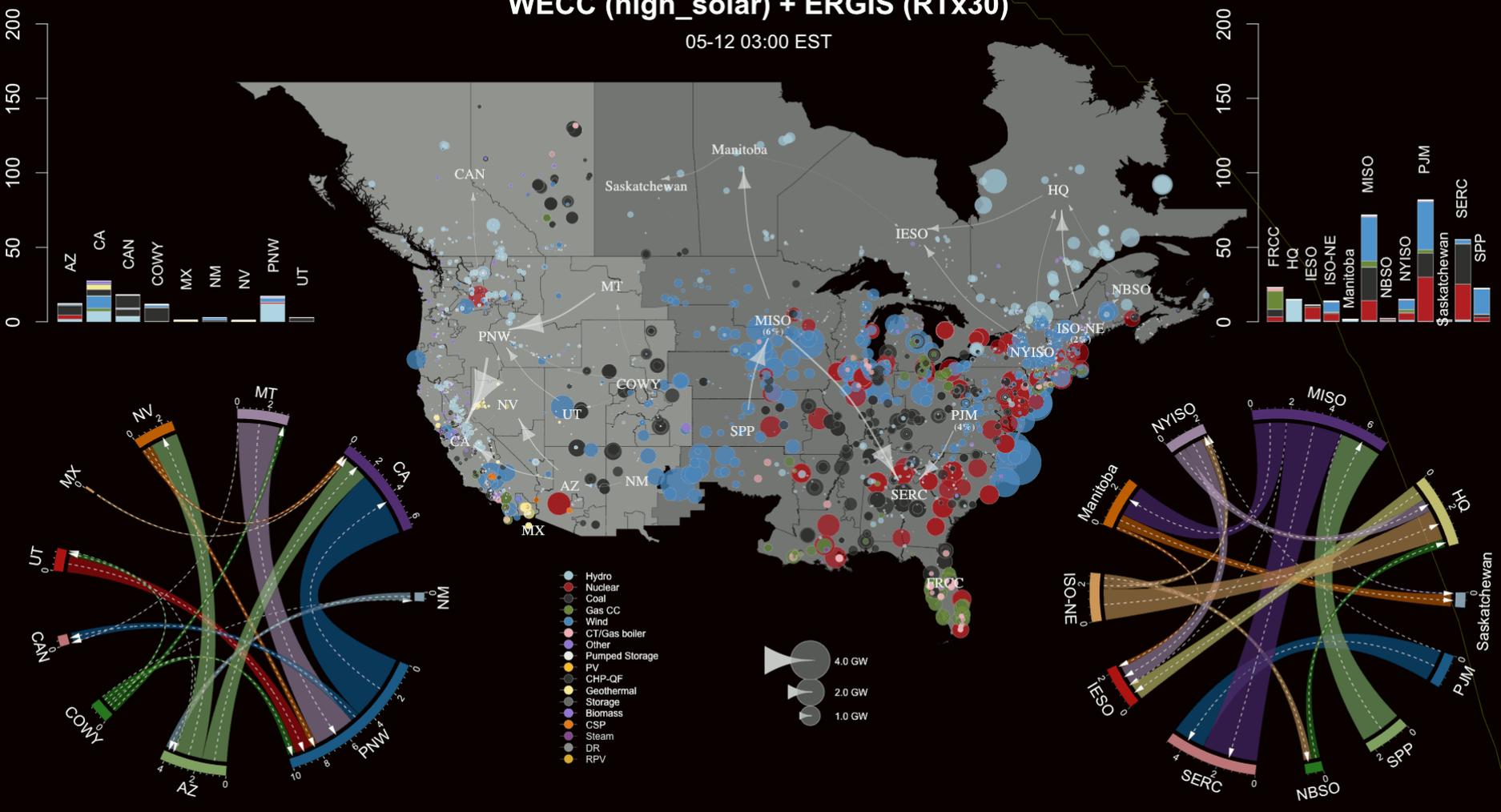


Kaleidoscope 1.0

(What you saw last time)

WECC (high_solar) + ERGIS (RTx30)

05-12 03:00 EST



Kaleidoscope—Alpha Update (What we've been up to)

PLEXOS Shiny Prototype

Generators

- Wind
- PV
- Hydro
- Coal
- Gas CC
- Gas CT
- Nuclear
- CHP-QF
- Geothermal
- Biomass
- CSP
- Steam
- DR
- RPV
- Other

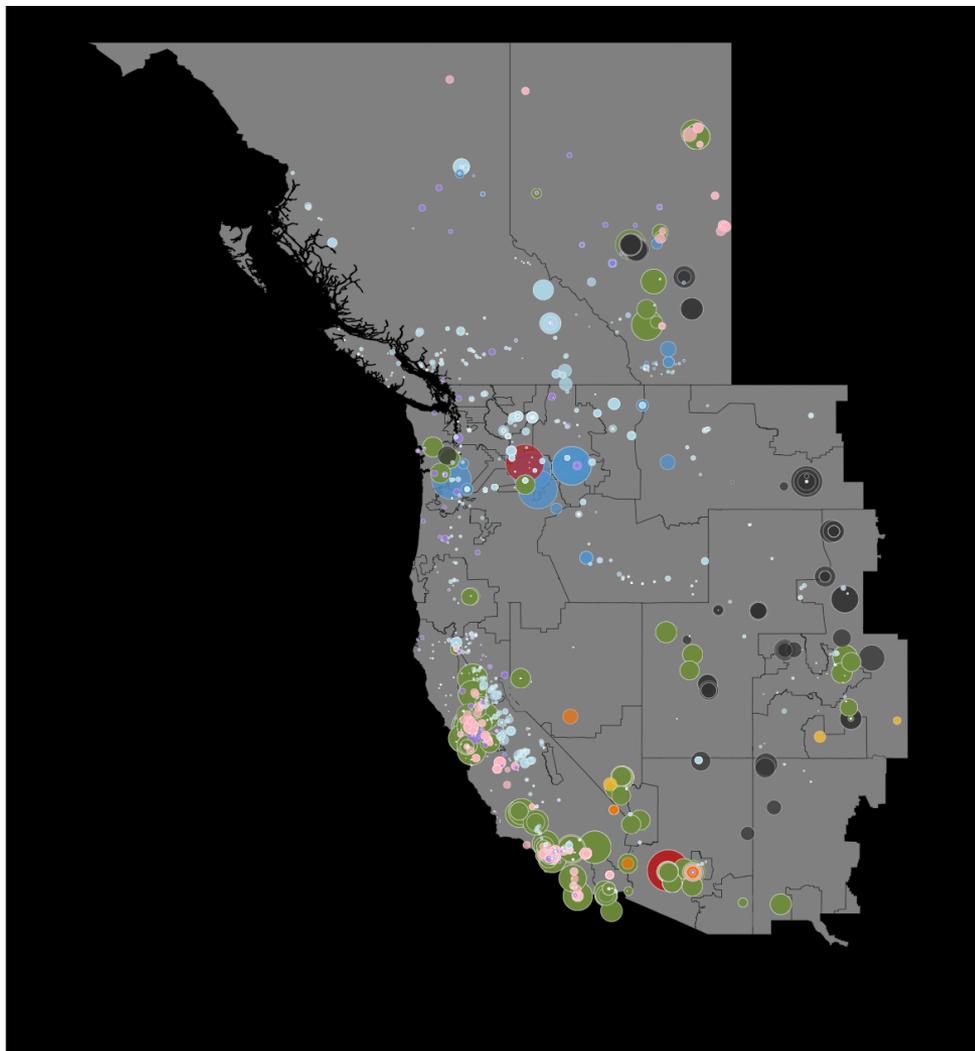
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Interconnections Seam Study

Project Integration and Collaboration

► Data

- Concentrating Solar Power (CSP)
- North American Renewable Integration Study (NARIS)
- Markets for Essential Reliability Services from Wind (Wind Reliability Markets)
- PowerUP
- Multi-scale Production Cost Modeling (Multi-PCM)

► TRC Coordination

- NARIS
- Multi-PCM
- PowerUP

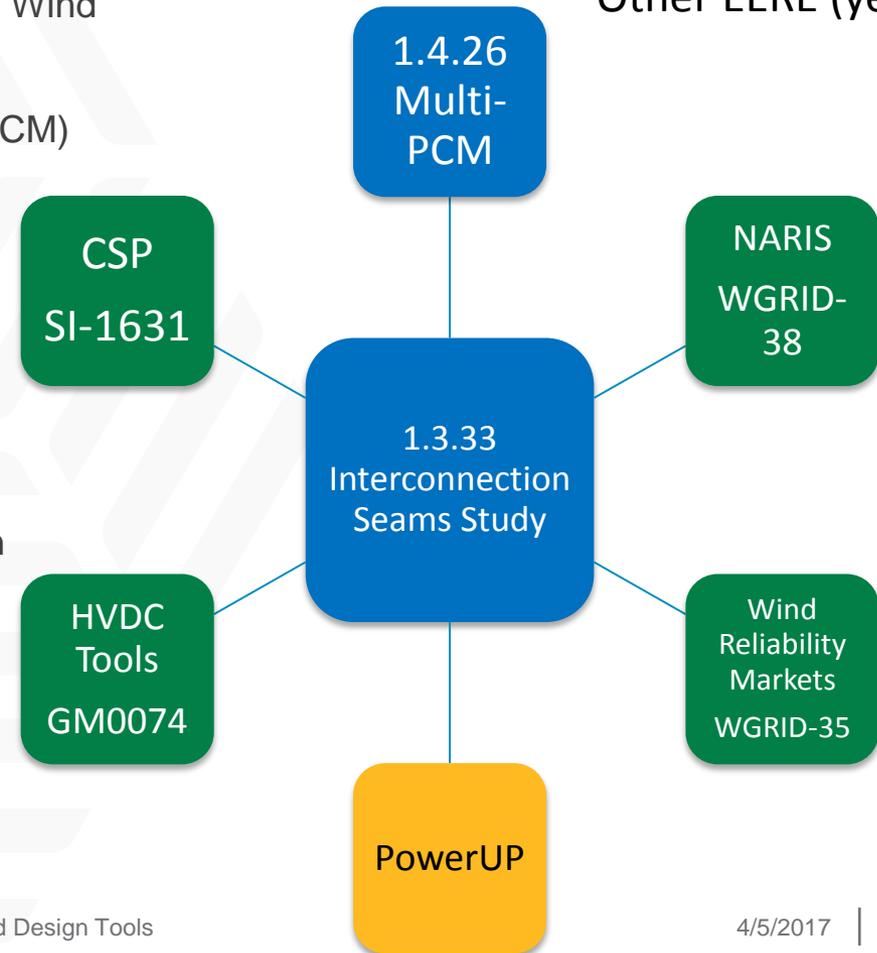
► Methods

- Multi-PCM
- NARIS
- Wind Reliability Markets
- HVDC for frequency response and congestion management (HVDC Tools)

► Tools

- CGT-Plan
- PLEXOS
- MAGMA
- Kaleidoscope
- PSS/E

Category 1 (blue)
Category 2 (green)
Other EERE (yellow)



Interconnections Seam Study

Project Integration and Collaboration



1. Eagle's Nest Transmission Summit
 - a. Aaron Bloom, NREL
 - b. September 2016
 - c. Location: New York
2. Utility Variable Generation Integration Group (UVIG) Forecasting Workshop
 - a. Aaron Bloom, NREL
 - b. October 2016
 - c. Location: Denver, CO
3. Wind Energy Seminar.
 - a. James McCalley, "Renewable-motivated co-optimized expansion planning of generation, transmission, distribution, and natural gas systems."
 - b. <http://home.eng.iastate.edu/~jdm/wesep594/Fall2016.htm>.
 - c. September 6, 2016
 - d. Iowa State University, Ames Iowa.
4. 2016 International Conference on Probabilistic Methods Applied to Power Systems, keynote talk.
 - a. James McCalley, "Co-optimized Expansion Planning Applications and Uncertainty."
 - b. <http://www.pmaps2016.org/index.php?m=content&c=index&a=lists&catid=12>
 - c. October 17, 2016.
 - d. Tsinghua University, Beijing, China.
5. Transmission Summit West Executive Forum Case Study: Exploring Connecting WECC and the Eastern Interconnect
 - a. Jay Caspary, SPP
 - b. September 2016
 - c. San Diego, CA
6. Transmission Summit West Panel Discussion: Perspectives on Regional Planning, Interregional Coordination and Competitive Projects
 - a. Jay Caspary, SPP
 - b. September 2016
 - c. San Diego, CA
7. Midwestern Governors Association--Grid Modernization: Understanding Technology Advancements Conference Panel Discussion: Transmission and Interconnection in the Era of Modernization
 - a. Jay Caspary, SPP
 - b. October, 2016
 - c. Columbus, OH
8. EPRI Power Delivery and Utilization 2016 Fall Advisory Council Meeting
 - a. Doug Bowman, SPP
 - b. September, 2016
 - c. Hollywood Beach, FL
9. SPP Overview and the Future Grid Kansas Field Conference
 - a. Jay Caspary, SPP
 - b. August 18th, 2016
 - c. Garden City, KS
10. Bulk Power System Overview and It's Evolution to the Future Grid, Harding University IEEE Student Meeting
 - a. Jay Caspary, SPP
 - b. September 22nd, 2016
 - c. Searcy, AR
11. DOE Electricity Advisory Committee meeting, EI-WECC Seams Study Update
 - a. Jay Caspary, SPP
 - b. Dale Osborn, MISO
 - c. September 28, 2016
 - d. Arlington VA
12. ARPA-e, A Unified Grid
 - a. Dale Osborn, MISO
 - b. September 29, 2016
 - c. Washington, DC
13. EPRI Power Delivery and Utilization 2016 Fall Advisory Council Meeting
 - a. Dale Osborn, MISO
 - b. September, 2016
 - c. Hollywood Beach, FL
14. EUCI 2017 Transmission Summit
 - a. Rebecca Johnson, WAPA
 - b. February 27 and 28, 2017
 - c. Orange County, CA
15. Transmission Summit 2017
 - a. Jay Caspary, SPP
 - b. March 6, 2017
 - c. Washington DC
16. SPP Seams Steering Committee
 - a. Jay Caspary, SPP
 - b. March 8, 2017
17. Utility Variable Generation Integration Group
 - a. Jim McCalley, ISU
 - b. March 13-16
 - c. Tucson, AZ

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Next Steps and Future Plans



Next Steps

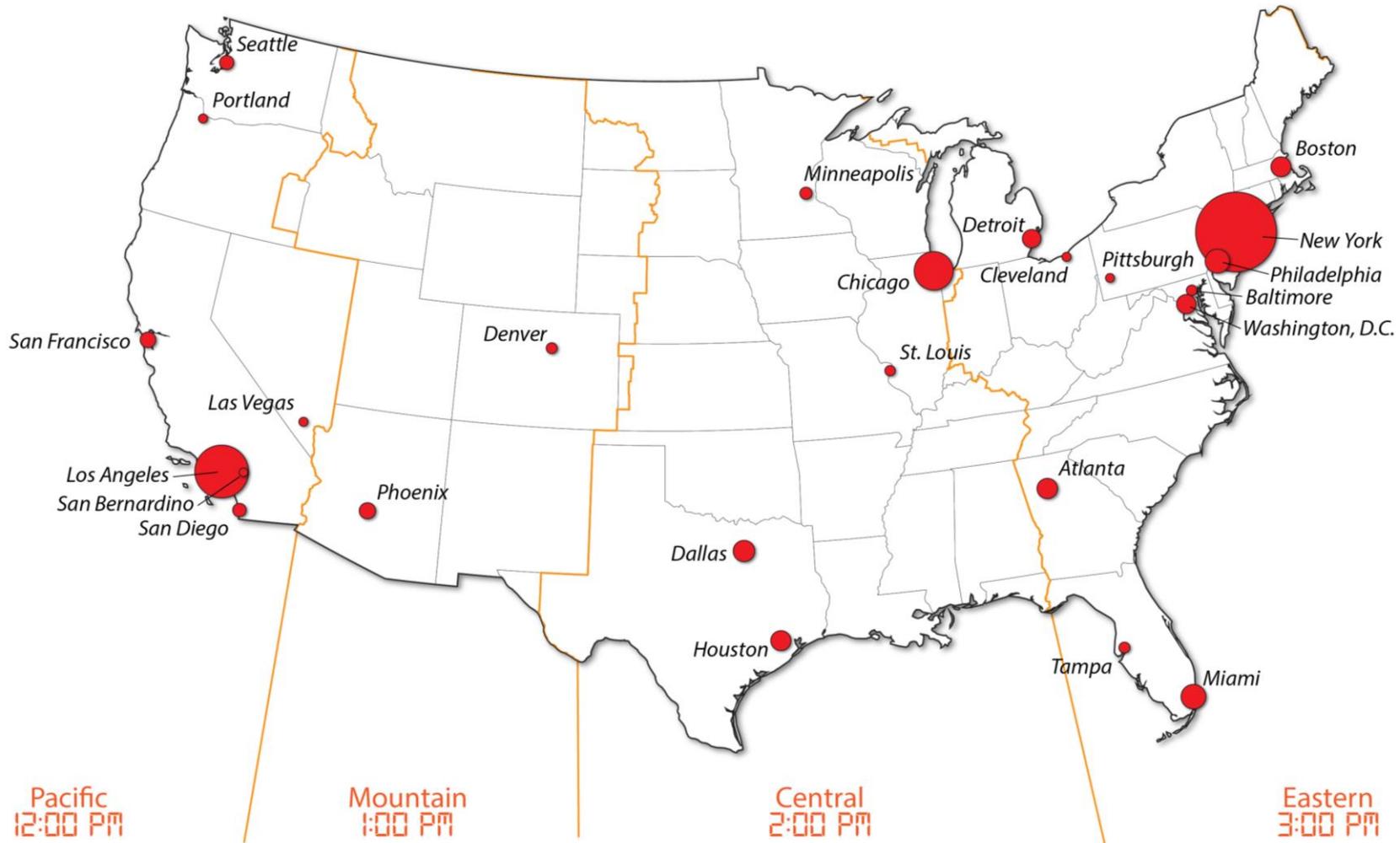
- ▶ May 17
 - TRC Meeting
- ▶ Finalize CEP scenarios and sensitivities
- ▶ Present 2026 PCM results
- ▶ Sync PCM and Steady State models
- ▶ Conduct 2038 PCM runs
- ▶ Conduct 2038 Stead State runs

- ▶ Final Report October 1, 2017

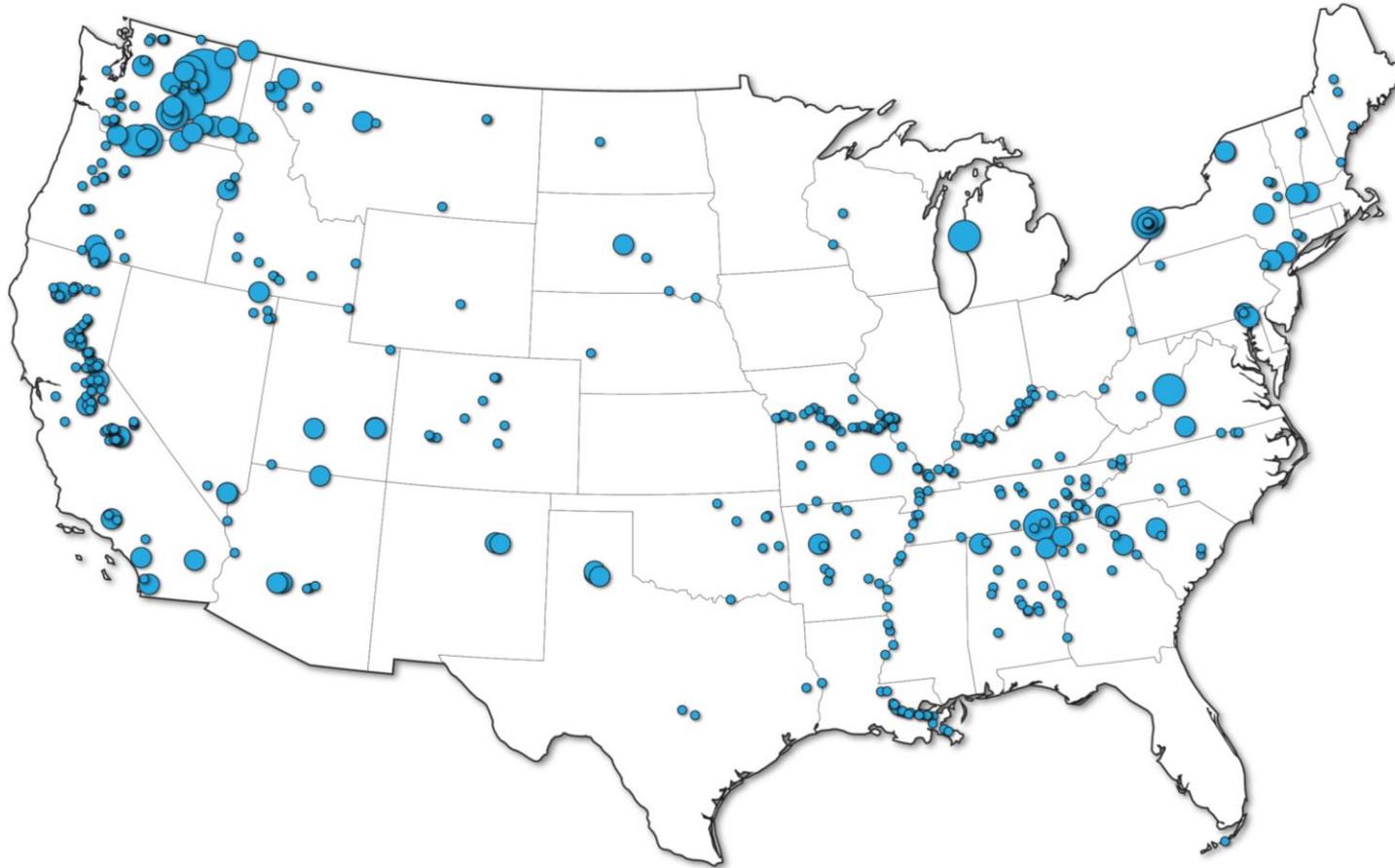
Wish list

- ▶ HVDC Operational Practices
- ▶ Weather Sensitivity
- ▶ State level communications products
- ▶ Natural Gas Sensitivity
- ▶ Add ERCOT!

U.S. Demand for Electricity is Diverse



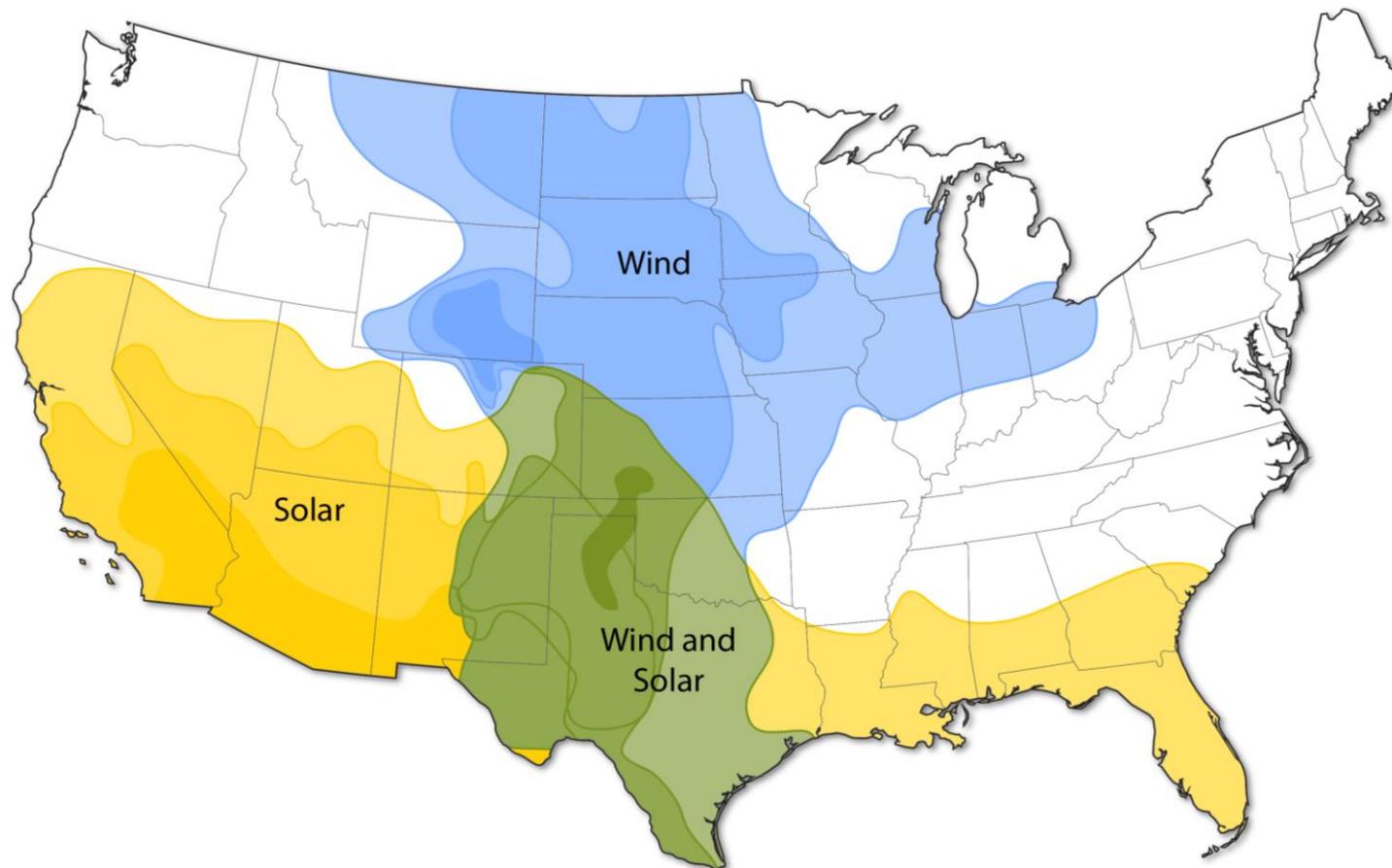
River Basins are Diverse



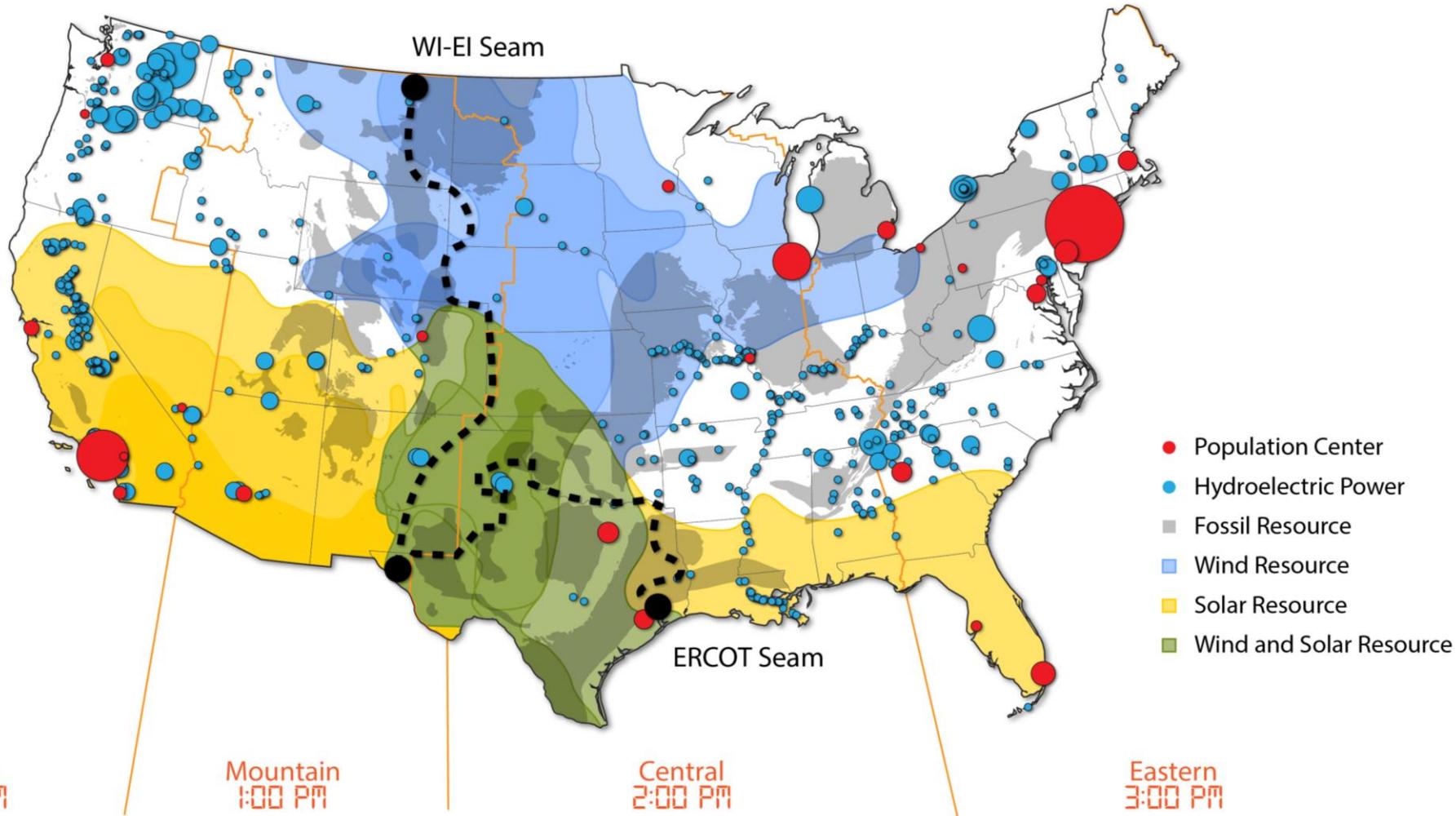
Fossil Fuel Reserves are Broadly Available



U.S. has Exceptional Wind and Solar



The Resources are Split Up



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